Volume 11 DECEMBER 1, 1936 Number 6

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

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PROGRAM

FOR THE

PASADENA MEETING

AT

THE CALIFORNIA INSTITUTE OF TECHNOLOGY

DECEMBER 18–19, 1936

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
SEVEN ISSUES EACH YEAR

The American Physical Society

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AMERICAN PHYSICAL SOCIETY

Published seven times per year

Subscription price: $5.00 per year

Single copies: $1.00 each

The Bulletin of the American Physical Society is published seven times a year during the months of February, April, June (2 issues), November (2 issues), and December at Prince and Lemon Streets, Lancaster, Pa.

Address correspondence to Prince and Lemon Streets, Lancaster, Pa., or to Secretary W. L. Severinghaus, Columbia University, New York, N. Y.

Entered at the post office at Lancaster, Pa., as second class matter.

Acceptance for mailing at a special rate of postage provided for in the Act of October 3, 1917, embodied in paragraph 4, Section 412, P. L. & R., authorized April 28, 1928.

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PASADENA MEETING

THE 210th regular meeting of the American Physical Society will be held at the California Institute of Technology, Pasadena, California, in the lecture hall, room 201, of Norman Bridge Laboratory on Friday, December 18 and Saturday, December 19, 1936. Morning and afternoon sessions will be held, starting at 9:30 and 1:30 o'clock, respectively.

Symposium on the 200-inch telescope. On Saturday morning invited papers on problems related to the telescope project will be presented by Dr. John Strong and Dr. J. A. Anderson, who will also conduct an inspection tour of laboratories and shops engaged in work on the telescope. Dr. Strong will speak on "The Evaporation Process and its Application to Optical Surfaces." Dr. Anderson's title will be "Some Problems Connected with the 200-inch Telescope."

Atlantic City Meeting. The preliminary arrangements of the Atlantic City program include a symposium on "Radiological Physics" and a joint session on Tuesday, December 29, with Section B of the American Association for the Advancement of Science and the American Association of Physics Teachers, at which time the retiring vice president of Section B, John T. Tate, will deliver an address on "Electron Impacts in Gases." There will also be an address by the president of the American Physical Society, F. K. Richtmyer, on "Multiple Ionization of Atoms." The dinner will be held on Tuesday, December 29, at the Chalfonte Hotel.

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General Rules Relating to Papers

Only those titles of papers shall be listed on the preliminary program of a meeting of the Society for which abstracts ready for publication are in the hands of the Secretary.

On October 29, 1936, the Council voted that:

No papers may be accepted for presentation at any meeting of the Society subsequent to the closing date stated in the printed call for that meeting.

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program. (A paper presented by two or more authors is assigned to the first named author.)

All supplementary papers will be grouped according to subject matter and will be called for at their appropriate sessions only, these sessions to be designated on the program. The presiding officer may assign a reduced time to these papers or may in his discretion call for them to be read by title only.

Except by special vote of the Society, the maximum allowance of time for the presentation of a paper shall be ten minutes. The presiding officer shall enforce this rule.

Titles and abstracts of the papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction the abstracts will be published in an early number of the *Physical Review*. Authors should send corrections to the Publications

Manager, The American Institute of Physics Incorporated, 175 Fifth Avenue, New York, N. Y.

Other meetings for the current season are as follows:

211. December 28–30, 1936. Annual Meeting. Atlantic City, New Jersey.
212. February 19–20, 1937. Chapel Hill and Durham, North Carolina.
213. April 29–May 1, 1937. Washington, D. C.

PAUL KIRKPATRICK
Local Secretary for the Pacific Coast
Stanford University, California.

December 1, 1936.

CALENDAR

Friday morning, December 18
9:30 o'clock: Room 201: Papers No. 1–11. See pages 4–6.
Friday afternoon, December 18
1:30 o'clock: Room 201: Papers No. 12–23. See pages 7–9.
Saturday morning, December 19
9:30 o'clock: Room 201: Symposium on the 200-inch telescope, with inspection tour starting from Room 201.
Saturday afternoon, December 19
1:30 o'clock: Room 201: Papers No. 24–33. See pages 9–11.

PROGRAM

FRIDAY MORNING, 9:30 A.M.

Room 201, Norman Bridge Laboratory

1. A Method for Sealing β-Magnesia Windows Into Steel Spectroscopic Absorption Furnaces and a Needle Valve for Controlling the Evacuation of Such Furnaces. R. T. BRICE, *California Institute of Technology*.—The resistance of β-magnesia to etching by hot metallic vapors has been utilized to construct a spectroscopic absorption furnace in which the absorption chamber is in thermal equilibrium. A seal is made by grinding and polishing the edge of a ½″ diameter by ¼″ thick β-magnesia window to a 1° taper and forcing it into a similar taper in a soft aluminum or copper rod. The soft metal rod is then turned down to 0.020″ wall thickness, using the same taper, leaving a window tightly fitted into a protective collar. A smooth inside-taper is cut in a thick-walled, hollow steel bolt and the encased window forced into this taper. The result is a β-magnesia window tightly sealed in a heavy steel casing which can be easily sealed into an absorption furnace with aluminum, copper or nickel gaskets. Windows mounted with aluminum were tested at 435°C without leaking and a window mounted with copper was tested at 587°C. To control evacuation of the furnace, a stainless-steel valve has been built which seals an opening in the wall of the furnace, does not produce a cold spot, and can be manipulated from outside the furnace. It has worked satisfactorily over a period of eight months. The upper limit of temperature for use of the β-magnesia seals and stainless-steel valve has not been determined.

2. Recording Apparatus for the Measurement of Integrated Intensities of X-Ray Reflections. O. B. JACKSON AND A. GOETZ, *California Institute of Technology*.—The apparatus is used as an integral part of a Bragg-spectrometer with stationary ionization chamber. It is designed especially for simultaneous measurements of $\int J d\vartheta$ and J_{max} at low temperatures. In principle the device consists of a mechanical coordination of the movement of a narrow slit in front of the ionization chamber with the movement of a photographic plate upon which the deflections of a galvanometer are recorded. The galvanometer indicates by means of a d.c. amplifier the current in the ionization chamber. The difference between this method and the usual method of determining the integrated intensity consists in keeping crystal and x-ray tube stationary and moving the slit of the ionization chamber. The resolving power is thus increased considerably whereas the records obtained for different orders are not directly commensurable due to the mosaicness of the crystal. By means of an empirically determined factor the comparison can be made possible. The integration is performed by weighing cut-out prints of the records on photographic paper.

3. Further Studies of the C. T. R. Wilson Condensation on Charged Carriers Using Various Liquids. LEONARD B. LOEB, A. F. KIP, A. W. EINARSSON, *University of California*.—Previous investigations reported at the Washington meeting June 19, 1936, have been extended to the substances detailed below. Aside from the addition of three new substances showing preference for the negative ion, the studies of mixtures brought out the following facts. While pure acetic acid has positive preference and water has negative preference the mixtures of any large proportion of either showed no sign preference as might be expected. The limit for condensation on ions was lowered below the value for either constituent as had been observed elsewhere in the case of alcohol and water. This should follow from vapor pressure laws. HCl and water mixtures show no deviation from pure water at all concentrations. This shows that uncharged molecules of HCl vapor do not form nuclei of condensation. These experiments revealed the formation of the stable uncharged

nuclei so often found, to be due to droplets of HCl and water vapor that had condensed about ions or uncharged particles by a previous expansion, and that had not evaporated completely, but had lost their charge.

No sign preference

	Condensation Ratio Charged $E_{\pm}$	Uncharged E_0
Acetone $(CH_3)_2CO$	1.88	2.06
Acetic Acid $+H_2O$	1.24	1.33

Negative Ion Preference

	E_-	E_+	E_0
Aniline $C_6H_5NH_2$	1.44	1.48	—
Chlorobenzene C_6H_5Cl	1.53	1.60	1.80
Toluene $C_6H_5CH_3$	1.60	1.69	1.73
H_2O+HCl	1.27	>1.3	1.37

4. Electron and Negative Ion Mobilities in Oxygen, Air, Nitrous Oxide, and Ammonia. Russell A. Nielsen and Norris E. Bradbury, *Stanford University*.—The electrical shutter method for measuring electron mobilities in gases has been extended to include experiments in oxygen, air, nitrous oxide, and ammonia. The experimental data support the hypothesis that collisions of low energy electrons with molecules of these gases may be inelastic. Such collisions cause excitation of vibrational levels, electronic levels, or dissociation of the molecule. The results are compared with experiments reported elsewhere on negative ion formation in these gases. In general the onset of negative ion formation is accompanied by inelastic collisions which result in a marked increase in the electron drift velocity.

Negative ion mobilities in these gases have been measured in the same apparatus by an adaptation of the Rutherford alternating current method. The ions were formed by electron attachment in an auxiliary field and their mobility determined at various ages. The probable character of the ions is discussed after comparing the experimental results with those predicted by the Langevin theory.

5. A New Radioactive Isotope of Fluorine. Arthur H. Snell, *Radiation Laboratory, University of California (Introduced by Ernest O. Lawrence)*.—When neon gas is bombarded with 5 MV deuterons, an active product is formed which emits positive electrons and decays with a period of 112 ± 4 minutes. This active substance behaves chemically like fluorine, and since it is neither of the two known radiofluorines, F^{17} and F^{20}, it must be F^{18}. The reaction describing its formation is then

$$_{10}Ne^{20}+{}_1H^2 \qquad {}_9F^{18}+{}_2He^4$$

and in decaying it goes to stable O^{18}. Absorption measurements of the positrons indicate that they have a maximum energy of about 500 kv.

6. The Energy and Absorption of the Gamma-Radiation from Lithium Bombarded by Protons. L. A. Delsasso, W. A. Fowler, C. C. Lauritsen, *California Institute of Technology*.—Further cloud chamber studies of pairs and single particles ejected from a thin Pb scatterer by the gamma-radiation from Li^7+H^1 have confirmed the existence of a strong line at approximately 17.5 Mev. There is some indication of a line at approximately 14 Mev, the intensity of which is not more than 15 percent of the total radiation.

Collimation of the beam has reduced markedly the number of single positrons and low energy electrons apparently originating in the scatterer, without materially changing the number of pairs. The distribution in energy of the Compton electrons is in fair agreement with the predictions of the Klein-Nishina theory.

In order to measure the absorption coefficient of the radiation, the cloud chamber photographs were taken with a 1.0 cm Pb absorber placed alternately in and out of the beam incident upon the scatterer. The total number of pairs observed decreased from 328 with no absorber to 194 with the absorber in the beam, whereas the number of pairs above 15 Mev decreased from 233 to 122. The total absorption coefficient in Pb of the unmodified radiation producing pairs above 15 Mev is thus $\mu=0.65\pm0.09$ cm^{-1}. The theoretical Klein-Nishina absorption coefficient for 17.5 Mev radiation is $\sigma=0.09$ cm^{-1} while the Oppenheimer-Bethe-Heitler absorption coefficient is $\pi=0.62$ cm^{-1}, the total absorption thus being $\mu=0.71$ cm^{-1}, a value with which the observed coefficient is in agreement.

7. The Radioactivity Induced in Calcium under Deuteron Bombardment. Harold Walke,* *Radiation Laboratory, University of California (Introduced by Ernest O. Lawrence)*.—Calcite crystals have been bombarded in the Berkeley cyclotron with 5.5 million volt deuterons and have been rendered strongly radioactive. Several decay periods have been observed, chemical analyses indicating that most of the activity is due to scandium isotopes. The decay of the weak calcium activity shows evidence of only a single period with a half life of 2.3 ± 0.3 hours, whereas the scandium shows periods of 53 ± 3 minutes 4.0 ± 0.1 hours and 52 ± 2 hours. The results of Zyw[1] and of Hevesy[2] suggest that the half lives of Sc^{42} and Sc^{46} are 3 hours and greater than a year, respectively. It is thus possible that the isotopes observed are Sc^{41}, Sc^{43} and Sc^{44} produced by reactions of the type:

$$Ca^N+H^2 \qquad Sc^{N+1}+n^1.$$

The 4-hour period is probably due to Sc^{43} for this half life agrees with the value given by Frisch,[3] namely "4.4 hours with a possible error of 10 percent."

Using the strong source available, an attempt has been made to induce radioactivity in calcium by neutron bombardment. Weak activities, probably due to impurities, have been detected, though the results are not consistent. No evidence of the 4-hour period observed by Hevesy and Levi[4] has yet been obtained.

* Commonwealth Fund Fellow.
[1] Zyw, Nature **134**, 64 (1934).
[2] Hevesy, Nature **135**, 1051 (1935).
[3] Frisch, Nature **136**, 220 (1935).
[4] Hevesy and Levi, Nature **135**, 580 (1935).

8. Are There Metastable Molecules in the Lewis-Rayleigh Glow? Joseph Kaplan, *University of California at Los Angeles*.—During the preparation of nitrogen tubes for the emission of the auroral afterglow, observations were made which give an answer to the above question. When the nitrogen is being purified by repeated flashing

of the tube, a stage is reached, at which the tube shows the Lewis-Rayleigh glow, which is the one characterized by members of the first-positive group only. On further purification, this glow is replaced by the auroral afterglow, the spectrum of which contains the first-positive, second-positive, Vegard-Kaplan and first-negative systems. When pure oxygen is added to this tube, the afterglow is increased in intensity, but the spectrum retains its auroral characteristics, although changes occur in the relative intensities of the bands. It appears that once a tube shows the auroral glow, the addition of pure oxygen does not produce the L–R glow. These, and other results, indicate that no relation exists between these two glows. The absence of the Vegard-Kaplan and the Goldstein-Kaplan bands from the L–R glow is further indication that there are no metastable molecules in this glow. This contradicts the hypothesis presented sometime ago by Cario and the present author.

9. The Thirty Kilowatt Continuous-Rating X-Ray Outfit of the Watters Memorial Research Laboratory at the California Institute of Technology. J. PAUL YOUTZ AND JESSE W. M. DUMOND, *California Institute of Technology.*—Reporting steady operation of DuMond gyrating target x-ray tube at 105 m.a., 287,000 volts continuous current. Output ¾ kw of x-rays. Water-cooled gyrating target facilitates focal spot cooling. Tantalum cathode filament (40 mil diam. 30 amp. 5 v) provides stiffness and long life. Gold covered copper targets used. ¼″ target-filament gap shielded against field distortion and stray or secondary electrons. Filament current supplied by storage batteries kept charged by two d.c. (automobile) generators, the latter insulated from ground for 500 kv and driven by 72″ rubber V-belts. Adequate lead shielding built into the x-ray tube throughout so that the usual lead house is unnecessary. Filament current control remote regulated by horizontal, fixed length, variable section, mercury rheostat. Water circulating in rubber hose used as part of all principal circuit connections to stabilize against surges. Indicating equipment for operation includes DuMond-Knudsen vacuum gauge. Neon lamp by-pass protects against surges through milliammeter. Obstruction charcoal traps directly heated for baking-out, by imbedded heater, assist in clearing system of vapors slow to pump by oil diffusion pumps. Standard voltage doubling power circuit using four banks 150 kv, 1/12 mfd, condensers and two 300 kv kenotrons with 80 mil, 100 amp., 1 kw filaments, baked out before operation by 5000 v a.c. direct to plate. 125-cycle synchronous motor driven alternator supply. Operation comparable with 10 m.a., 50,000 v sets. Steady and quiet, reliable, very compact, occupies 6 m×6 m ×3.2 m.

10. The Coefficient of Recombination of Pure Oxygen as a Function of Pressure and Temperature. M. E. GARDNER, *University of California* (*Introduced by Leonard B. Loeb*).—A re-determination of the coefficient of recombination, α, for the electron free gas oxygen was made by using a glass chamber which was thoroughly outgassed prior to the introduction of carefully purified oxygen. The value of α was found to be a constant independent of age from 10^{-2} seconds on to 1 second for pure oxygen at constant pressure and temperature. The value of α obtained at atmospheric pressure and room temperature was $(2.0\pm0.1)10^{-6}$. The value of α as a function of the pressure of the gas was found to be in fairly good agreement with the theoretical values of J. J. Thomson for pressures of 10 cm to one atmosphere. The variation of α with temperature was not in such good agreement with the theoretical values as the pressure variations. The deviations from the theoretical values can be partially explained in terms of the experimental difficulties involved.

11. Relations Between the Self-Consistent Field and Bohr's Nuclear Model. W. M. ELSASSER, *California Institute of Technology.*—In Bohr's semiclassical model the nucleus is equivalent to a degenerate gas and it is shown that any excitation energy will in the most probable case be divided among a large number of particles. Starting from a self-consistent Hartree-Fock model as used for instance by Bethe in computing the term density, we can express the quantum equivalent of this picture as follows. The spectral density of terms being very great, their energetic spacing will be much smaller than their mutual interaction under a perturbation which corresponds to the difference between the selfconsistent and the true Hamiltonian. Treating a great number of terms as degenerate together, the new wave functions will be linear combinations of a large number of Hartree-Fock functions. For the lowest terms however the spacing is quite considerable and therefore the original features of a self-consistent field, in particular the formation of "closed shells," will not get entirely lost under the perturbation. This agrees with the well-known empirical behavior of nuclear binding energies. The author has previously shown that these variations are empirically stronger for even than for odd nuclei. This is in full agreement with the above considerations, if allowance is made for forces between like particles.

FRIDAY AFTERNOON, 1:30 O'CLOCK

Room 201, Norman Bridge Laboratory

Paper No. 19 will be read by title.

12. The Refractive Index of Air in the Infrared. DAVID BENDER, *California Institute of Technology.*—There is some disagreement among the experiments on the refractive index of air in the infrared. The results of Perard (1924) are about 0.2 percent higher than those of the Bureau of Standards (1918). More recent results have agreed more closely with Perard than with the Bureau, and have tended to be even higher. The present measurements, though unfinished, also lie above Perard's values, being on the average 0.4 percent higher than those of the Bureau. The measurements are being made on dry CO_2-free air with a Fabry-Perot interferometer having a separation of 14 or 21 millimeters. Neon lines have been used exclusively and wave-lengths out to 8853A have been observed up to the present time. The total fringe shift ranges from 8 to 15 fringes and the error in the order of interference is about 0.005 fringes. Thus the error in the index from this source is about 0.05 percent. The pressure and temperature measurements are accurate to within 0.08 percent. Although the spread in the individual index measurements covers nearly 0.03 percent, the inaccuracy of the final curve will be considerably less than 0.1 percent.

13. A Method of Removing the Errors of Tooth Spacing to Produce High Precision Worm Gear Wheels by Lapping. DOUGLAS MARLOW AND JESSE W. M. DUMOND, *California Institute of Technology.*—We describe a rapid and cheap method of reducing and distributing the initial errors of tooth spacing in a worm gear wheel by constructing it in two halves with half the width of each tooth in each half. The wheel is lapped with emery using a dummy worm, the two halves of the wheel being shifted relative to each other according to a certain schedule between stages of lapping. We show that the proper angular intervals for such shiftings should be integer powers of $\frac{1}{2}$ a revolution. The method has been tried on the construction of two highly precise worm gear wheels for a two crystal x-ray spectrometer. By precise optical tests we have determined that on the better of these two wheels making abstraction of the slight eccentricity the greatest deviation of teeth (cumulative error) from the mean position was of the order one ten thousandth of an inch. A further application of the method could doubtless have still improved this.

14. Table of Observable Interstellar Lines. R. M. LANGER, *California Institute of Technology.*—Recent advances in technique which have made possible brighter spectra in the ultraviolet regions have led Mt. Wilson astronomers to look for new absorption lines due to atoms in interstellar space. Calculations by the writer of the intensity and spectral distribution of interstellar light together with published tables of term values of atoms and ions permit the determination of all observable lines which can be expected from the interstellar gas. An exhaustive table of this material is being prepared. Approximate relative intensities can be expressed in terms of relative abundances. Absolute abundances can be determined only when the electron concentration is known. This depends mainly on the relative abundance of hydrogen. The relative abundance according to the present theory of the two elements which have long been known, namely sodium and calcium, is about 30 to 1. This figure is about ten times the apparent relative abundance in the sun. The discovery of any new lines will most likely show whether this discrepancy is real.

15. Precision Determination of h/e from the Short Wave-Length Limit of the Continuous X-Ray Spectrum. VERNON L. BOLLMAN AND JESSE W. M. DUMOND, *California Institute of Technology.*—Two precision determinations of the short wave-length limit of the continuous x-ray spectrum have been made in the regions of 10,000 and 20,000 volts, respectively, by the method of isochromats under very steady applied voltage using the two crystal spectrometer as monochromator. The reference lines for setting the monochromator were Mo $K\beta_2$ and W $L\beta_1$. A thin window tube with a nickel target coated with tungsten by evaporation was used. Very careful attention has been given to all corrections.

On the assumption that the ruled grating x-ray wave-lengths are correct (Mo $K\beta_2 = 0.6211 \times 10^{-8}$ cm, W $L\beta_1 = 1.2818 \times 10^{-8}$ cm) we get $h/e = 1.3767 \times 10^{-17}$. Making no such assumption but inserting the value of the x-ray wave-lengths as a function of e from the data on crystal density, the Faraday constant and x-ray diffraction and solving for e we get $e/h^{3/4} = 2.0715 \times 10^{10}$. The results on this experiment agree with those of previous experimenters much better than they agree with other methods of determining functions of e and h and the present experiment confirms and emphasizes the puzzling discrepancy in these physical constants already emphasized by Birge. It seems well nigh impossible to blame the present experiment for this discrepancy. By elimination we are led to suspect the correctness of accepted values of the Faraday constant.

16. Carrier Mobility Spectra in the Electrification by Spraying and Bubbling of Liquids. SEVILLE CHAPMAN, *University of California* (*Introduced by Leonard B. Loeb*).—Data previously reported on the mobility spectrum of spray electrified salt solutions investigated with an Erickson mobility tube under conditions of high resolving power have been extended to a larger number of substances. Results for these are similar to those previously obtained. Data on the electrification of distilled water by bubbling show that there are carriers of both signs produced although the negative predominate in the ratio of 2.5 to one. Bubbling gives somewhat more sharply defined groups of carriers than spraying, the groups for bubbling occurring at mobilities 1.2 cm/sec. per volt/cm and 0.25 for the negative, and 0.7 and 0.3 for the positive. Preliminary work on the spraying of nonaqueous liquids shows that for benzene there is no electrification. Water free absolute

alcohol shows pronounced groups of mobilities at 1.0 and 0.3, the electrification in this case being about 12 times that for distilled water. Nitrobenzene, aniline, and glacial acetic acid do not show pronounced groups, the spectra being more or less continuous, although few carriers of mobility greater than 0.5 were found. The total amounts of electrification for these three substances are roughly the same as for distilled water.

17. On the Continuous β-Ray Spectrum of P^{32}. W. E. LAMB, JR., *University of California* (*Introduced by J. R. Oppenheimer*).—The results of Lyman on the form of the continuous β-ray spectrum of P^{32} are not in agreement with the Konopinski-Uhlenbeck plots. Some improvement in the fit may be obtained if one uses the K. U. ansatz, but applies it to find the distribution for the 3rd Sargent curve, which is probably the correct one for P^{32}, although the discrepancy is still beyond experimental error. One can, however, obtain an almost perfect agreement with experiment by an ansatz for the coupling which depends only on first derivatives of the neutrino wave functions. For this, one may take for the coupling term in the Lagrangian, a sum of two scalars, one of which may be written as the product of heavy and light particle six vectors, and the other as product of one pair of the corresponding pseudovectors.

18. The Radioactive Isotope of Potassium. W. R. SMYTHE AND A. HEMMENDINGER, *California Institute of Technology*.—Using the high intensity mass-spectrometer described by Smythe, Rumbaugh, and West,[1] we have separated samples of the three isotopes of potassium, K^{39}, K^{40}, and K^{41}. The radioactivity of the collector bearing the isotopic sample can be compared with that of a dummy collector by swinging them alternately in front of a thin aluminum walled Geiger-Müller counter mounted inside the apparatus and admitting the proper amount of air for counting. The background of the counter is extremely steady at one count per minute. Two complete sets of samples were tested. One sample of K^{40}, probably considerably less than the 20.4/8300 mg estimated from the uncorrected collecting current, doubled the original activity of the collector, whereas the samples of K^{39} and K^{40} showed only the activity to be expected from the known amount of K^{40} present, which was 7 percent of the natural abundance. Comparison with counts made on weighed samples of potassium chloride indicates that K^{40} is responsible certainly for the low energy beta-particles and very probably for those of high energy also.

[1] Smythe, Rumbaugh and West, Phys. Rev. **45**, 724 (1934).

19. Optical Absorption of Fused Germanium Dioxide from 0.185μ to 8.5μ. R. WILLIAM SHAW, *Cornell University*.—Studies by Laubengayer[1] have shown that the values of refractivity and dispersion of fused germanium dioxide in the visible spectrum are both considerably higher than for silicon dioxide in the same chemical family. The ultraviolet transmission, unlike that of quartz, is zero from 0.315μ to 0.185μ for a sample 2 mm thick. Immersion in liquid nitrogen moves the transmission limit 160 angstroms toward shorter wave-lengths. No appreciable absorptions appear from 0.315μ to 2.86μ. At the latter point a characteristic absorption is observed. Between 2.86μ and 4.5μ the transmission is again normal except for a shallow (5 percent) but narrow band at 4.24μ which seems to have an analogue at 2.26μ. From 4.5μ the transmission decreases rapidly to zero at 6.15μ with a characteristic inflexion in the curve at 5.40μ. From 6.15μ to 8.5μ the 2 mm sample is opaque. Fused germanium dioxide exhibits then a uniform transmission from the near ultraviolet to 4.5μ except for one sharp absorption at 2.86μ. This absorption is very nearly symmetrical and might conceivably be suitable for calibration purposes in the near infrared. The Raman spectrum of germanium dioxide, excited by the Hg line λ3650, is a single band. The frequency interval between the band center and the parent line corresponds to the wave-length 2.88μ. Details will be published in the near future.

[1] A. W. Laubengayer, J. Phys. Chem. **30**, 1510 (1926).

20. The Band Spectra of BiF, BiCl, SbF, and SbCl. GEORGE D. ROCHESTER,* *University of California*.—Three new systems of bands, degraded to shorter wave-lengths and forming a triplet system with wide multiplet separations (7300 cm^{-1} and 4800 cm^{-1}), have been found in the spectrum of BiF at 3050–3250A, 2650–2850A, and 2250–2350A. Photographs taken with small dispersion indicate that the ω values for the ground and excited states are approximately 520 cm^{-1} and 620 cm^{-1}. No new band systems have been found in BiCl. The spectrum of SbF has been observed from λ2000–λ5500 and found to have groups of bands in the regions 3600–5200A, 2600–2700A and 2200–2430A. An analysis of the first group shows that 61 out of 69 bands can be placed into two systems with almost the same values of ω_e' and ω_e''; the wave numbers of the bandheads are given by the formulae:

$$\nu_1 = 21887.5 + 411.3(v'+\tfrac{1}{2}) - 1.71(v'+\tfrac{1}{2})^2 - 616.9(v''+\tfrac{1}{2}) + 2.89(v''+\tfrac{1}{2})^2,$$

$$\nu_2 = 23992.5 + 420.0(v'+\tfrac{1}{2}) - 1.75(v'+\tfrac{1}{2})^2 - 612.6(v''+\tfrac{1}{2}) + 2.58(v''+\tfrac{1}{2})^2.$$

The group at 2600–2700A consists of a few isolated bands degraded to shorter wave-lengths and that at 2200–2430A of bands grouped in sequences and also degraded to shorter wave-lengths. A preliminary analysis of this group indicates that most of the bands fit into two systems for which $\omega_e' \sim 700$ cm^{-1}, $\omega_e'' \sim 620$ cm^{-1}, and $\Delta\nu_{12} \sim 1900$ cm^{-1}. A new system has been found in the spectrum of SbCl in the region 4000–5500A.

* Commonwealth Fund Fellow.

21. Analysis of the Linear Amplifier.* H. TATEL, *Stanford University*.—An attempt has been made to improve the empirical linear amplifier used with a Wynn-Williams ionization chamber to detect α-particles. This investigation has been divided into two parts. First the signal to noise ratio was determined analytically by resolving the pulse into a Fourier integrand and multiplying it by an amplifier function $(\omega^n/\omega_0)e^{-\alpha\omega}$ where ω is the circular frequency. Upon integration, the output voltage was compared to the random noise voltage generated in the input stage as given by Johnson† and using the amplifier function

above. Neglecting shot noise, $n=2$ and $\alpha=0.577T$ (T is the collection time). The r.m.s. of the signal to noise ratio is

$$\overline{\rho^2}=4.46\times10^{10}N(R/T)$$

(N is the number of ions collected, R is the input resistance).

The second part of the investigation has been aimed at reducing natural α-particle background. This was achieved by designing the chamber so that any surface at which a detectable α-particle could originate could easily be removed and rinsed in concentrated nitric acid. Experience has shown that this procedure keeps the background consistently below 5 α-particles per 100 cm² of brass per hour.

* A large part of this was done at the Massachusetts Institute of Technology.

† J. B. Johnson, Phys. Rev. **32**, 97 (1928).

22. Positive Ion Mobilities in H_2 by the Townsend Deflection Method. ALLAN V. HERSHEY, *University of California (Introduced by Leonard B. Loeb).*—The mobility of positive ions at low pressure and at high X/p is being studied as a function of field strength by means of the Townsend deflection method. From preliminary measurements with ions presumably K^+ having a molecular weight of 39, the mobility constant in H_2 was found to be 13.5 at $p=0.7$ and at $X/p=5$ (p=pressure in mm, X=field strength in volts/cm), in excellent agreement with values obtained by Powell and Brata.[1] At the same pressure and at $X/p=50$ the mobility constant was 30 percent greater.

[1] Powell and Brata, Proc. Roy. Soc. **A138**, 117 (1930).

23. Method for the Production of Metal Single Crystals Between 20μ and 0.2μ. J. RINEHART AND A. GOETZ, *California Institute of Technology.*—In order to measure the dependence of electromagnetic properties of metal crystals upon their size, it is necessary to avoid plastic deformation during the production of the crystal. As the methods used in general for the production of fine single-crystalline powders consisted of the application of mechanical methods such as grinding, etc., a new method was developed by which the metal is sprayed while liquid by the application of a high pressure gas (100–150 atm.) at a temperature above the melting point of the metal. The resulting metal dust crystallizes while hovering in an oil fog. The particles are then separated by sedimentation and centrifuging in order to obtain suspensions of crystals of equal size which are then oriented crystallographically parallel after the method of Goetz and Faessler.

SATURDAY AFTERNOON, 1:30 O'CLOCK

Room 201, Norman Bridge Laboratory

24. The Modified Scattered Spectrum of Characteristic Molybdenum K Radiation at Large Scattering Angle with Helium Gas as the Scattering Substance Using a Curved Quartz Crystal Spectrograph. HARRY A. KIRKPATRICK AND JESSE W. M. DUMOND, *Occidental College and California Institute of Technology.*—After an exposure of over two thousand hours with a curved quartz crystal spectrograph and a scattering chamber one meter long with celluloid window containing helium gas under 200 lbs./in.² pressure, we have obtained what we believe to be the first actual spectrum of Compton shifted radiation ever made with a gaseous scatterer. This permits a comparison of the observed breadth and structure of the modified line with the absolute predictions of DuMond's theory for an atom of sufficient simplicity to permit the electron momentum distribution to be computed and this without the uncertainties introduced by the perturbing effects of neighbors (always present in previous work with solid scatterers). A fairly precise measurement of shift is also obtained in which the Ross and Kirkpatrick shift defect is minimized by the choice of He as scatterer. Preliminary measurements support the theoretical expectations.

25. The Effect of Mercury Vapor on the Townsend Coefficient, α, in Pure Nitrogen. WOODFORD E. BOWLS, *University of California (Introduced by Leonard B. Loeb).*—In conjunction with an investigation of the apparent effect of cathode material on β, the second Townsend coefficient of ionization by collision, in nitrogen, the values of α, the coefficient of ionization by electrons, have been evaluated. The measurements have been carried out in a carefully baked out, mercury free, chamber. The values of α/p have been determined in a range of X/p from 215 to 1000. (p is the pressure in millimeters of mercury and X, the field strength in volts per centimeter.) The values of α/p obtained were approximately 80 percent of the values obtained by Townsend. Since the original ionization chamber of Townsend contained mercury, it was thought advisable to ascertain whether the presence of mercury could account for the difference in the values of α/p. When mercury was admitted to the chamber, values of α/p approximately 96 percent of the Townsend values were obtained. Outgassing up to 375° centigrade for twenty-four hours did not suffice to restore the low values completely. Removal of the mercury by dismantling of the chamber and chemically treating all the parts nearly restored the low values.

26. Intensities of X-Ray Reflections from Bi Crystals Between 25° and 530° Abs. ALEXANDER GOETZ AND ROBERT B. JACOBS, *California Institute of Technology.*—The temperature variations of the integrated intensities of reflections of Mo $K\alpha$ radiation from Bi crystals on (111) are measured over a range near the boiling point of hydrogen to the melting point by means of the modified Bragg method using the second, third, and fifth order. The temperature functions of the relative values of the intensities (J_T/J_N) were checked with the Debye-Waller relation. By an approximation method the characteristic temperatures of Bi were calculated without (θ) and with (θ^*) consideration of the zero point energy. The values thus

obtained are $\theta=92.5°$ and $\theta^*=95.9°$. The latter value is in very close agreement with θ-values determined from specific heat measurements. The measurements support the assumption of the zero point energy.

No indication of a discontinuity of the intensity was found in the regions of pseudo-allotropic transformations.

A deviation from the Debye-Waller relation is noticeable for higher temperatures, especially in a range 50°–80° before the melting point in the direction of an absolute increase of the Debye factor. This increase is reversible if the crystal is kept in thermal equilibrium, shows, however, a hysteresis if this is not the case. This phenomenon can be interpreted as being due to a temperature dependence of the secondary extinction.

27. The Thermal Expansion of the Bi Lattice Between 25° and 530° Abs. ROBERT B. JACOBS AND ALEXANDER GOETZ, *California Institute of Technology.*—The thermal expansion of the lattice of Bi crystals between the boiling point of hydrogen and within 7° of the melting point of the crystal is measured by means of a modified Bragg method along [111] for the 2nd, 3rd and 5th order. The thermal expansion coefficient thus obtained (α_{11}) varies from 8.3 $\times10^{-6}$ to 17.4$\times10^{-6}$ for the temperature range $\theta\geq T$. Beyond 120° α_{11} stays unchanged until the melting point. Only the range between −15°C and +75°C forms an exception where the expansion coefficient drops to 13.8 $\times10^{-6}$. This seems to indicate the existence of a separate "phase" not characterized by a change of the lattice configuration and confirms certain previous findings of discontinuities at 75° (Peltier effect, diamagnetic susceptibility, chemical affinity, dilatometric expansion). In qualitative agreement with findings by Goetz and Hergenrother and in disagreement with the measurements of Jay, a definite divergence between the lattice and the integral expansion beginning 30° before the melting point was found. The Grüneisen rule ($\alpha_{11}/c_p=$const.) is found to hold in first approximation for the whole temperature range, except the very lowest temperatures.

28. The Fine Structure of Hα and Dα. WILLIAM V. HOUSTON, *California Institute of Technology.*—By means of the method of analysis described at the Seattle meeting of the Physical Society[1] the interferometer patterns of Hα and Dα have been studied with changes in the conditions of excitation and with different separations of the interferometer plates. The analysis has involved the assumption of four components located at approximately the positions given by the theory for the four strongest components of this pattern. The best fit is obtained when the separation of the two strongest components is about 2 percent less than the theoretical value. The intensity of the third strongest component is always considerably greater than its theoretical value, even at pressures as high as one millimeter. In no case does there seem to be any difference between Hα and Dα except the difference in width due to the temperature motion.

[1] Phys. Rev. **50**, 292 (1936).

29. A New Band of Atmospheric Oxygen. HAROLD D. BABCOCK, *Mount Wilson Observatory.*—With the discovery and measurement of the 1,1 band of ordinary oxygen[1] an accurate determination of the vibrational energy of the normal molecule became possible. This permits the computation of positions of lines in bands, theoretically existent but not previously observed, which arise from the same lower state as the 1,1 band but involve other vibrational levels of the upper state. The band 1,2, having the same upper level as the α band near λ6276, is predicted accurately from the observational data. About twenty lines belonging to it have been measured, λλ6955–6996, with air-paths of about 100 km. The identity of the new band is established by the close agreement between computed and observed positions and by the character of the lines themselves. Known spacings of various energy levels in the molecule are shown by the new band within a few hundredths of a wave number. An improved value of the vibrational constant from 1,1 and 1,2 and full details of these and other bands are being prepared for publication. The strongest lines of 1,2 resemble the sixteenth and seventeenth *P* doublets of the *B* band in intensity.

[1] Babcock, Phys. Rev. **35**, 125 (1930).

30. The Magnetic Scattering of Slow Neutrons. L. JACKSON LASLETT, *University of California (Introduced by E. O. Lawrence).*—To determine whether the large cross sections for the scattering of slow neutrons by iron and nickel[1] arise in part from the ferromagnetic nature of these materials, a comparison of the back scattering at room temperature and above the Curie point was made. In conformity with the methods of earlier workers a thin silver piece was used as a detector of the incident and reflected neutrons, for it was found that with such a detector two thirds of the activity arose from *C*-group neutrons and that the difference in scattering between nickel and copper could be detected easily.

Because no significant change could be found in the scattering by iron and nickel as these elements were raised above their Curie temperatures, it is concluded that the largeness of their scattering cross sections is not of magnetic origin. In view of a calculation by Bloch[2] of the magnetic scattering to be expected in a ferromagnetic substance, however, this result does not preclude the neutron possessing a magnetic moment equal in order of magnitude to a nuclear magneton.

[1] A. C. G. Mitchell, E. J. Murphy and M. D. Whitaker, Phys. Rev. **50**, 133 (1936), and B. Pontecorvo and G. C. Wick, La Ricerca Scientif. [2] 1 (1934) and 220 (1936).
[2] Bloch, Phys. Rev. **50**, 259 (1936).

31. Fundamental Properties of Light From Distant Nebulae. F. ZWICKY, *California Institute of Technology, Pasadena.*—In order to arrive at a rational explanation of cosmological phenomena, such as the redshift of light from distant nebulae, it is necessary to establish a reference system of physical measurements on a cosmological scale. For this purpose a number of dimensionless ratios between fundamental physical quantities and their dependence on time and location must be investigated. The simplest inquiry of this kind refers to the properties of propagation,

diffraction, refraction and absorption of terrestrial light and "nebular" light respectively. Some data are already available on the aberration of light from distant nebulae as well as on the properties of this light when tested with prisms, gratings and suitable absorbing media. From these data we may conclude that the quantities c, h/c and h are the same within about five percent for terrestrial light and nebular light respectively. The more fundamental problem of the dependence of a number of dimensionless ratios on the "history" of the universe is still under investigation.

32. Polarization of the Solar Corona. WILLI M. COHN, *Berkeley, California.*—The polarization of the corona was determined from photographic plates taken during the total solar eclipses of 1932 and 1934.[1] The observations were favored by perfectly clear skies. Polarigraphs of 34- and 60-inch focal lengths were used, the quartz Wollaston prisms arranged in front of the objectives. Color screens of narrow transmission ranges were used for obtaining the polarization as a function of the wave-length. Intensity squares were printed on each corona plate right after the eclipses. The plates were measured by means of the Hartmann microphotometer of the Lick Observatory and the Zeiss microphotometer of the Physics Department, University of California. Polarization data are presented for wave-lengths 420, 447, 482, 668 mμ. The results show polarization values increasing, as a rule, from the limb of the sun towards the outer corona. The curves in the violet pass through a maximum, then decrease again. The curves for great wave-lengths are considerably steeper than those for small wave-lengths, indicating that electron scattering, alone, cannot be responsible for the light emitted from the corona.

[1] W. M. Cohn, Publ. Astron. Soc. Pacific **46**, 177–185 (1934).

33. The Removal of the Ion Beam of the Cyclotron from the Magnet Field. LUIS W. ALVAREZ, EDWIN MCMILLAN AND ARTHUR H. SNELL, *University of California (Introduced by Ernest O. Lawrence).*—Many obvious advantages can be obtained if the ion beam produced by the cyclotron is carried to some distance from its source, away from the magnetic field and the background of general radiation due to stray ions striking the inside of the apparatus. The first step in this direction was accomplished when the beam was made to emerge from the wall of the tank.[1] The chief difficulty in bringing it farther arises from the fact that the inhomogeneous field at the edge of the magnet poles causes the beam to diverge very badly. Exploratory experiments showed that, at a distance of 40 cm from the point of emergence, the beam was spread into a horizontal ribbon 10 cm wide, and continued to diverge at greater distances. A partial refocussing has now been accomplished by applying an additional inhomogeneous field, provided by pieces of iron bolted to the magnet poles. The focussed beam of 6 MV deuterons emerges at the end of a six-foot tube, well away from the cyclotron. Twenty-seven percent of the total current arrives at this point, mostly within a focal spot 3×3 cm in area. The beam is nearly parallel, and can be led much farther without much divergence. The rest of the current is not focussed by the present field, but can easily be saved by more careful design.

[1] Donald Cooksey and Ernest O. Lawrence, Phys. Rev. **49**, 866(A) (1936).

SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member one only of these will be assigned a place on the regular program while the others will be placed in a supplementary program to be called for if time permits.

Papers received after the program has been printed will be placed in the supplementary program.

The papers in the supplementary program may be called for only at the session indicated.

34. Positive Needle Point Corona Studies at Atmospheric Pressure. LEONARD B. LOEB AND W. LEIGH, *University of California.*—A study of asserted changes in shape and loss of material of positively charged needle points in sustained corona appearing in the literature reveals no real loss of material by sputtering but changes produced by oxidation in air, and the collection of dust etc. was observed in N_2 and in air. No uniform or systematic change in weight could be detected in as much as 1920 microampere hours at 20,000 volts. The fact that positive point corona discharge maintains itself and shows luminosity not only where fields incapable of producing ionization by positive ions, but even where fields incapable of causing electrons to ionize exist, has long required explanation. Studies reveal the corona to consist of many minute but finite transient streamers randomly propagated at great speed from the point and indicating by the blue spark spectrum high field gradients. These are superposed on the general background of arc spectrum. The corona can be explained as consisting of a random emission of minute leader strokes discharges such as observed in lightning probably induced by intense ionization avalanches started by single electrons approaching the point. Cravath and Loeb have given the theory of propagation of such strokes. The arc line glow is emission produced in the space between streamers by the subsequent discharges equalizing the potential gradients caused by space charges left by the extinguished preceding leader strokes.

35. An Anomalous Lightning Discharge. E. J. WORKMAN AND R. E. HOLZER, *University of New Mexico.*—In the execution of a lightning research program initiated by J. W. Beams, L. B. Snoddy and the authors, a photograph of lightning similar in appearance to that photographed by R. J. Spickerman and reported by C. G. Abbot[1] was obtained. The flash occurred near Santa Fe, New Mexico, and was recorded on the films of three rotating cameras. The drums of two of the cameras rotated about a vertical axis and that of the third about a horizontal axis. The analysis of the films, using the horizontal and vertical time sweeps, indicates that the velocity in space is approximately 5×10^8 cm/sec. This velocity is of the order of magnitude of the velocity obtained by Schonland for dart leader strokes.

Assuming a probable distance of four miles, the length of the visible portion of the stroke exceeds sixteen miles with the greatest spread exceeding three miles.

[1] Smithsonian Miscellaneous Collections, Vol. 92, No. 12.

Volume 11 DECEMBER 10, 1936 Number 7

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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

PROGRAM

OF THE

ANNUAL MEETING, ATLANTIC CITY, NEW JERSEY

DECEMBER 28–30, 1936

IN AFFILIATION WITH SECTION B—PHYSICS—OF
THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
SEVEN ISSUES EACH YEAR

The American Physical Society

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BULLETIN

of the

AMERICAN PHYSICAL SOCIETY

Published seven times per year

Subscription price: $5.00 per year

Single copies: $1.00 each

The Bulletin of the American Physical Society is published seven times a year during the months of February, April, June (2 issues), November (2 issues), and December at Prince and Lemon Streets, Lancaster, Pa.

Address correspondence to Prince and Lemon Streets, Lancaster, Pa., or to Secretary W. L. Severinghaus, Columbia University, New York, N. Y.

Entered at the post office at Lancaster, Pa., as second class matter.

Acceptance for mailing at a special rate of postage provided for in the Act of October 3, 1917, embodied in paragraph 4, Section 412, P. L. & R., authorized April 28, 1928.